BALL BEARING ROLLING DOWN A SLOPE

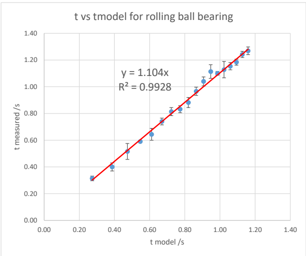
Andy French. Winchester College Laboratory P5. Wenesday 28th October 2020.

Ball mass m /g	13.74
Ball diameter 2r /mm	15.02
Strength of gravity g /Nkg^-1	9.81
Ramp height /mm	190
Ramp base /mm	977
Ramp elevation angle /deg	11.0
Ramp elevation angle /rad	0.192
14/5 * 1/(g*sin(theta))	1.495

$x = \frac{1}{2}\frac{5}{7} g\sin\theta\, t^2$

$$\boxed{t = \sqrt{\frac{14x}{5}\frac{1}{g\sin\theta}}}$$

Roll distance /cm	t1 /s	t2 /s	t3 /s	t4 /s	t5 /s	mean t /s	t error /s	Model t /s
5	0.29	0.30	0.32	0.34	0.32	0.31	0.02	0.27
10	0.42	0.38	0.42	0.43	0.35	0.40	0.03	0.39
15	0.44	0.58	0.50	0.59	0.47	0.52	0.06	0.47
20	0.58	0.60	0.58	0.59	0.60	0.59	0.01	0.55
25	0.65	0.65	0.56	0.69	0.67	0.64	0.04	0.61
30	0.77	0.71	0.72	0.73	0.77	0.74	0.03	0.67
35	0.85	0.85	0.78	0.80	0.79	0.81	0.03	0.72
40	0.82	0.81	0.84	0.88	0.81	0.83	0.03	0.77
45	0.91	0.93	0.88	0.87	0.82	0.88	0.04	0.82
50	1.00	0.99	0.92	0.94	0.98	0.97	0.03	0.86
55	1.04	1.10	1.02	1.04	1.00	1.04	0.03	0.91
60	1.03	1.17	1.12	1.16	1.09	1.11	0.05	0.95
65	1.10	1.08	1.11	1.12	1.09	1.10	0.01	0.99
70	1.09	1.18	1.06	1.22	1.09	1.13	0.06	1.02
75	1.18	1.15	1.12	1.19	1.13	1.15	0.03	1.06
80	1.16	1.16	1.19	1.22	1.19	1.18	0.02	1.09
85	1.28	1.25	1.23	1.21	1.24	1.24	0.02	1.13
90	1.27	1.25	1.23	1.32	1.27	1.27	0.03	1.16



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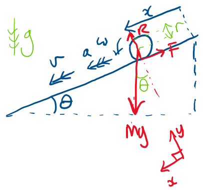
$$\boxed{t = \sqrt{\frac{14x}{5}\frac{1}{g\sin\theta}}}$$



NII:

$//x: \; Ma = Mg\sin\theta - F$

$//y: \; 0 = R - Mg\cos\theta$

Rotational motion:

($I\dot{\omega}$ = torque)

Sphere: $\rightarrow \boxed{I = \frac{2}{5}Mr^2}$

$I\dot{\omega} = Fr$

Now if no slip:

$F \le \mu R$

$v = r\omega \Rightarrow a = r\dot{\omega}$

$\therefore \dot{\omega} = a/r$

$\therefore I\dot{\omega} = Fr$

$\Rightarrow Ia/r = Fr$

$\Rightarrow a = Fr^2/I$

$\Rightarrow \boxed{F = Ia/r^2}$

$\therefore Ma = Mg\sin\theta - Ia/r^2$

$\therefore a = g\sin\theta - \frac{Ia}{Mr^2}$

$\therefore a\left(1 + I/Mr^2\right) = g\sin\theta$

$$\therefore \boxed{a = \frac{g\sin\theta}{1 + I/Mr^2}}$$

So since $I = \frac{2}{5}Mr^2$

$\Rightarrow I/Mr^2 = 2/5$

$\therefore 1 + I/Mr^2 = 7/5$

$$! \therefore \boxed{a = \frac{5}{7}g\sin\theta}$$

Kinematics:

$x = \frac{1}{2}at^2$

(roll from rest)

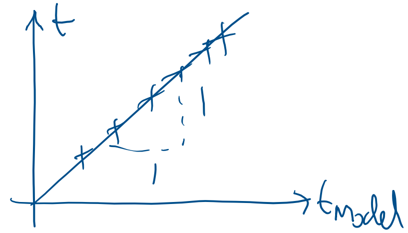
$\therefore x = \frac{1}{2}\frac{5}{7}g\sin\theta\, t^2$

$$\therefore \boxed{t = \sqrt{\frac{14x}{5}\frac{1}{g\sin\theta}}}$$

MODEL.

For various x in 5cm intervals, record t (fix θ).

Then plot t vs t_{model}



Hopefully a 1:1 correlation.